MOLECULAR PROPERTY SPECTROMETER™ (MPS™)
FLAMMABLE GAS SENSOR
EVALUATION UNIT USER MANUAL

NNTS Proprietary Information

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Table of Contents

System Overview and Setup

The Molecular Property Spectrometer^{TM} (MPS^{TM}) Flammable Gas Sensor Evaluation Unit is a user-friendly sensor system developed for assessing flammable gas detection performance. The evaluation system is shown in Figure 1. The sensor is 32.0 ⌀ x 13.8 mm with 1.5-mm connector pins and connects to a provided PCB for communication with a PC (USB) or breakout to individual sensor signals (optional 5-wire harness). The sensor contains the MPS MEMS sensing element, environmental sensor, microprocessor, and supporting electronics inside a flame-proof housing. A quarter-turn plastic gas mask and housing is included to provide a sealed headspace above the sensor for test gas delivery.

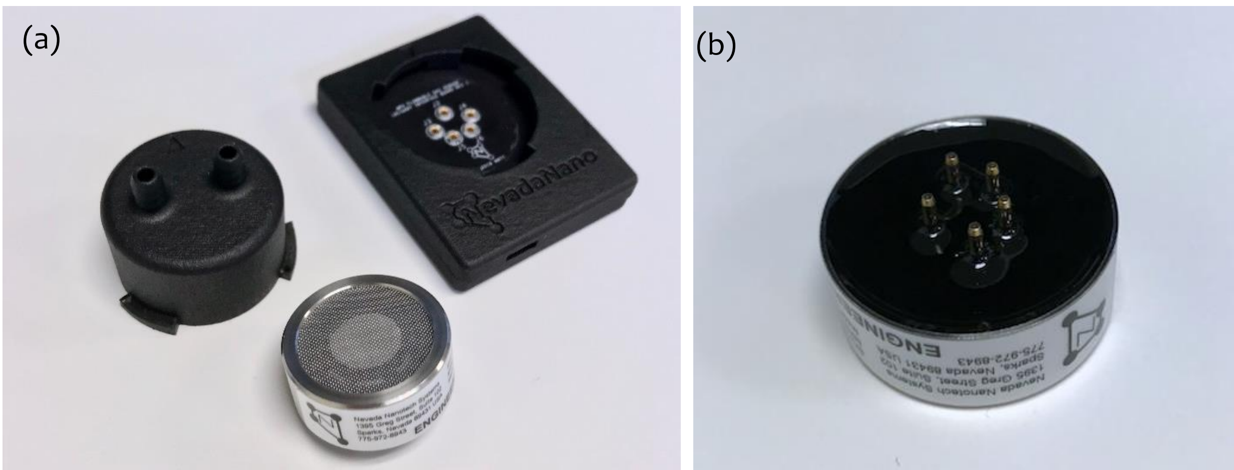

Figure 1 – (a) MPS s7 Flammable Gas Sensor, housing, and gas delivery mask. (b) Sensor bottom-side detail.

1.1 Kit Contents

The complete MPS^{TM} Customer Evaluation Unit kit consists of:

- MPS^{TM} S7 flammable gas smart-sensor
- MPS Sensor Interface software and drivers
- Sensor PCB + housing
- Gas delivery mask with integrated barbs
- USB A to micro B cable
- 1/4" Tygon tubing (McMaster: 6516T17)

1.2 Gas Testing Setup

The MPS measures molecular properties to determine the quantity of flammable gas present in a sample. The system is optimized for "real-world" cases. As such, the effects of humidity, temperature and pressure are automatically compensated out. However, sudden, wholesale changes to the molecular properties of the sample--i.e. artificial changes which can only be generated in a lab test rig--can lead to inaccurate MPS outputs. (This of course excludes changes due to the presence of flammable gas.) An example of an inadvisable change (shown in Fig. 2c, d) would be alternating between ambient air (which contains argon, carbon dioxide and other trace gases) and flammable gas + synthetic "zero air" balance (which contains none of the trace constituent gasses in ambient air). To simulate the real-world application (Fig. 2a) in artificial laboratory testing, the same type of "air" must be used for the background *and* the carrier of the flammable gas for the duration of the test. An example of a proper protocol is shown in Fig. 2b. Using a variation of the "incorrect" procedure will invalidate the accuracy of MPS measurements.

The best practice for performance testing in a laboratory is to use a humidified zero-air background, followed by a switch to a humidified analyte stream with the same zero-air composition as balance gas, then a switch back to humidified zero-air to clear the test chamber. This mimics real-world MPS performance, where flammable gas is introduced into relatively invariant ambient air (Fig. 2a).

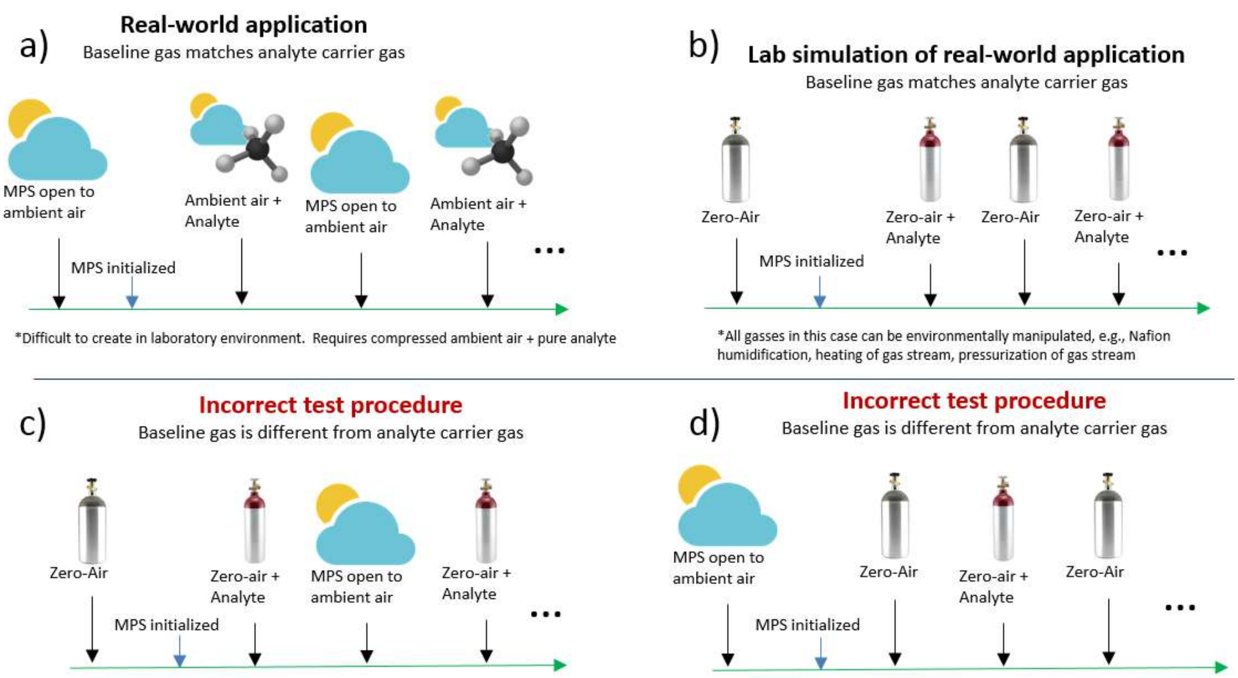

Figure 2 – Correct testing of MPS in (a) real-world application and (b) laboratory environments. Incorrect test procedures are shown in (c, d). In both cases, the analyte and carrier gas are dissimilar during the test, causing inaccurate results.

1.3 System Setup

The MPS Flammable Gas Sensor Evaluation Unit receives power and communicates to a PC via USB, or via UART through 5-wire harness with V+, V-, TX, RX, and Analog out (optional) connections. The MPS Sensor Interface is used to:

- establish communication with the sensor to start, pause, and end tests
- examine data in real-time
- record test notes
- save data to .csv file

The MPS Sensor Interface and accompanying drivers are available at:
https://www.nevadanano.com/MPS-Flammable-Gas-Sensor-Support

The user should first install the FTDI Driver, followed by a system restart, and then install the MPS Sensor Interface UI. The setup procedure follows:

1. It is recommended to always power the computer connected to the MPS since the sensor receives its power from the computer.
2. Connect the micro-USB cable to the MPS, then connect the opposite end of the USB cable to a USB port on the computer. The MPS will automatically receive power from the computer.
5. Using the supplied ¼ -in tubing, connect the test gas system to one of the integrated barbed connectors on the MPS gas mask.
    - Test gas should be supplied to the sensor at rates no greater than 300 mL/min.
    - The use of Nafion[1] tubing is recommended to humidify the test gas stream.
6. Attach the gas mask to the housing by aligning the arrow on the gas mask at the 10 o'clock position and inserting the three tabs into the housing. Turn the mask clockwise until the arrows on the housing and mask align and the mask "clicks" into place. The barbs will be aligned across the horizontal axis of the housing.

Figure 3 – Proper gas mask attachment is achieved when the arrow points align and the barbs are in the horizontal position.

[1] For more information on Nafion, including its permeability for various gases, refer to:
http://www.permapure.com/products/nafion-tubing/

7. Open the MPS Sensor Interface application from the desktop icon. 

8. Click the "Find MPS Devices" button and select the MPS Flammable Gas Sensor connected to the computer (Fig. 4). The sensor name is found on the sensor serial number in the form: B12318003.

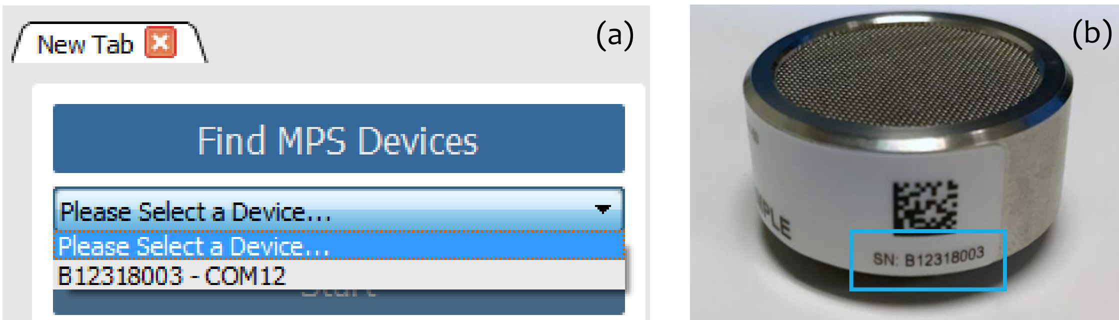

Figure 4 – (a) Selecting the active MPS™ Flammables device. (b) Sensor name indicator

9. The MPS sensor is now ready for testing. Proceed to *System Operation*, and read thoroughly before continuing

1.4 System Operation

Figure 5 shows a typical benchtop test setup. A calibrated gas cylinder (e.g., zero-air, 50%LEL methane in air) supplies gas from a 300-mL/min regulator via Nafion tubing to the gas mask. An example of a suitable regulator is a 70-series fixed flow regulator, which is compatible with 34, 58, 74, 103 and 116 Liter aluminum cylinders as well as 103 Liter steel cylinders. Flow can be stopped by removing the regulator or closing the black knob. The Nafion tubing humidifies the analyte gas stream to ambient humidity levels without appreciable loss of analyte. The experimental test area should have adequate ventilation to avoid exposure of gasses to the user. An additional zero-air gas cylinder should be applied to the sensor when analyte gas is not flowed.

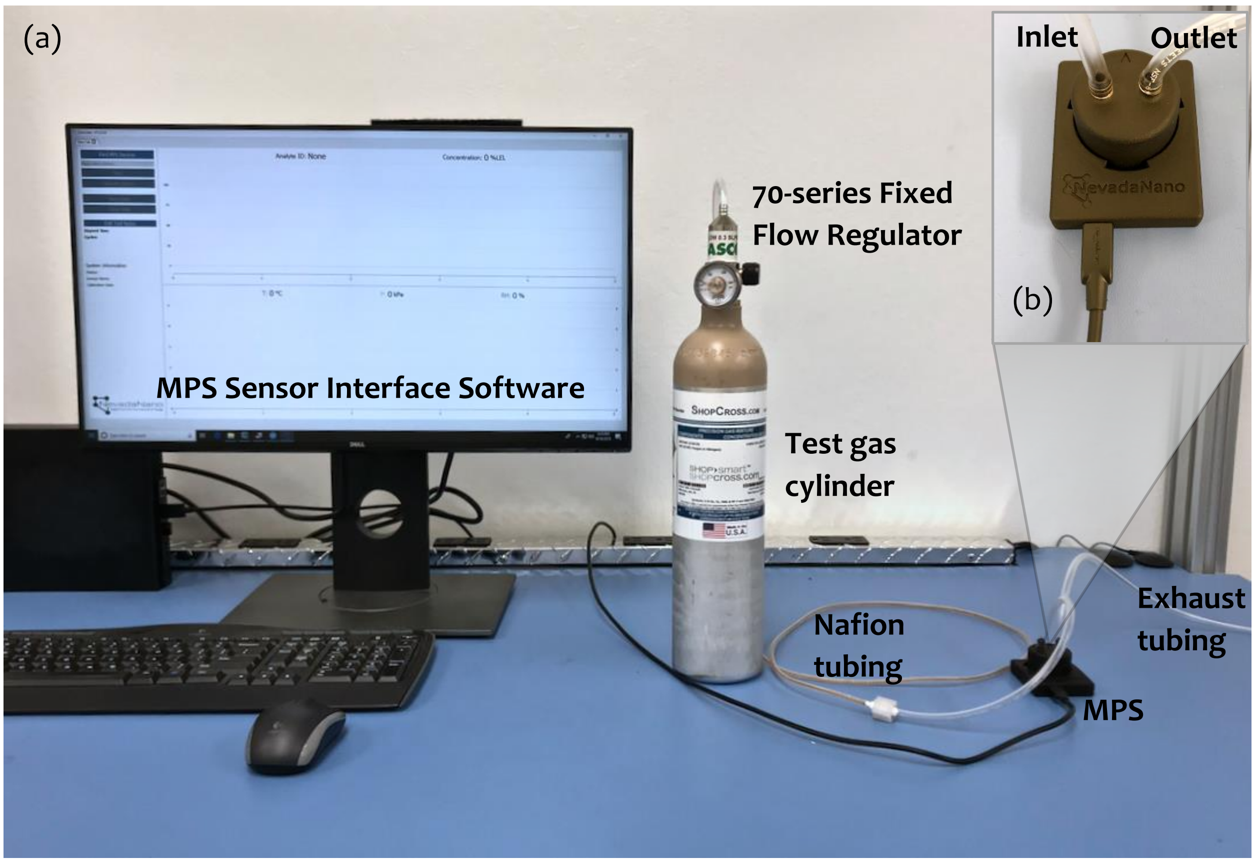

Figure 5 – (a) Typical test setup. (b) Detail gas and PC connections.

1.4.1 Conducting a Gas Test

1. After performing system setup (1.3), the start button will now be enabled (highlighted in green in Fig. 6). Start the flow of zero-air baseline gas over the MPS and wait ~1 minute before proceeding for baseline gas to replace ambient air. Click Start to begin the initial baseline acquisition.

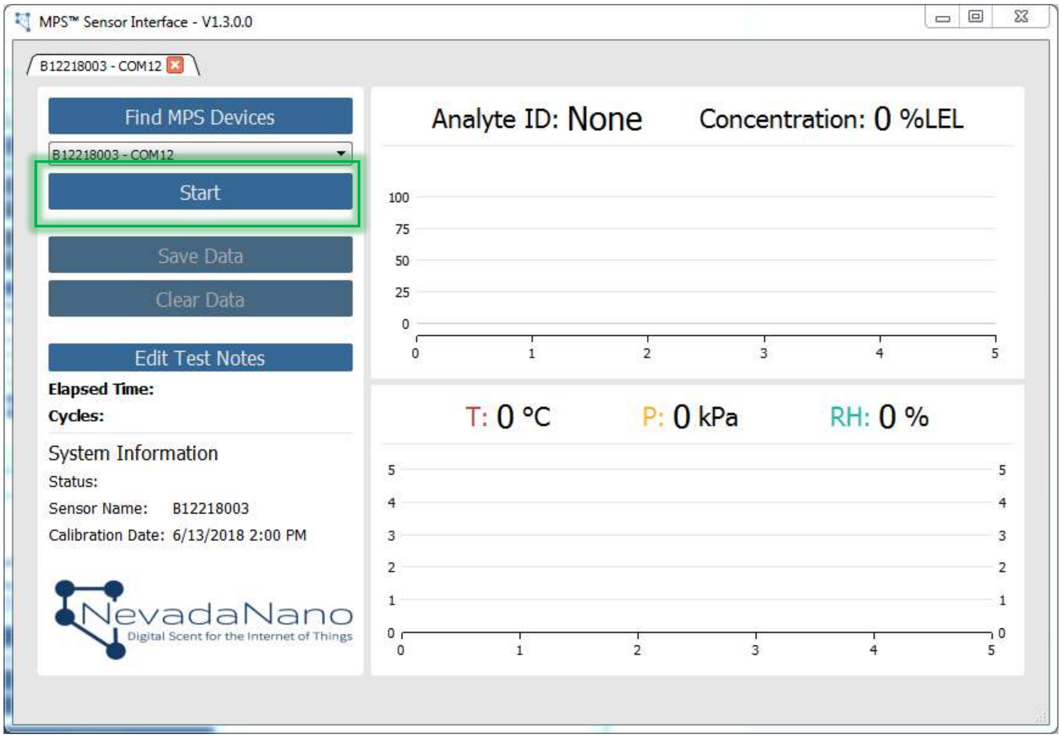

Figure 6 – MPS™ Flammables unit ready for testing. Sensor name is populated and start button is enabled.

2. The unit will acquire 10 baseline readings (Fig. 7, highlighted in green). After this stabilization period, the sensor is ready for testing.

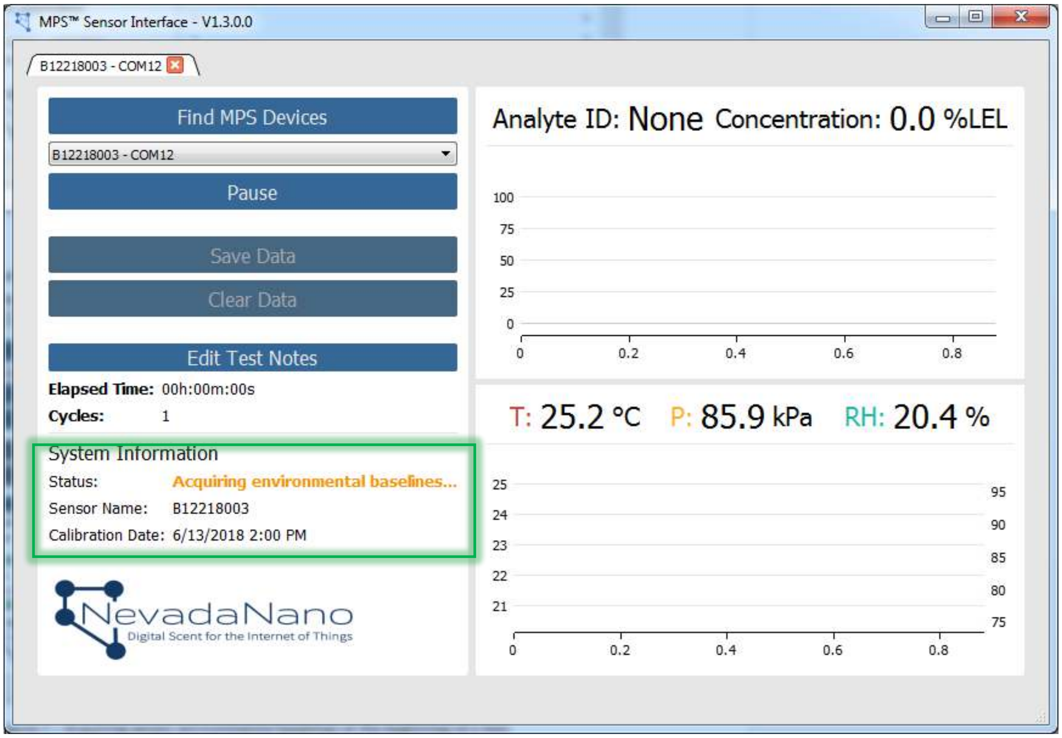

Figure 7 – Acquiring sensor environmental baselines at the beginning of a test.

3. Next, apply a test gas cylinder and note the results. A stable gas reading should be displayed within 30 seconds of applying a test cylinder as the supplied gas mask equilibrates with the tank concentration.
4. After removing the test-gas cylinder, reconnect to a zero-air cylinder to purge the test gas and continue to maintain a stable environment.
5. Repeat steps 3, 4 as needed to test various gasses and concentrations. When analyte is not tested, it is important to keep the baseline/zero-gas flowing as the MPS smart-algorithms will periodically record baselines.

1.4.2 System Shutdown

The MPS™ Flammables sensor must be in an idle state before shutdown. Pause the current test and wait for the system status dialogue to display "Idle", then save or clear the data. The USB cable can now be disconnected.

Data Collection & Analysis

During a test, the system generates a new data point every 2 seconds. Data can be visualized on the MPS Sensor Interface in real time throughout a test. Graphs can be resized and zoomed in and out while data are being collected. An example screenshot is shown in Fig. 8. Graphs can be reset to auto-scale by double clicking on the desired axis.

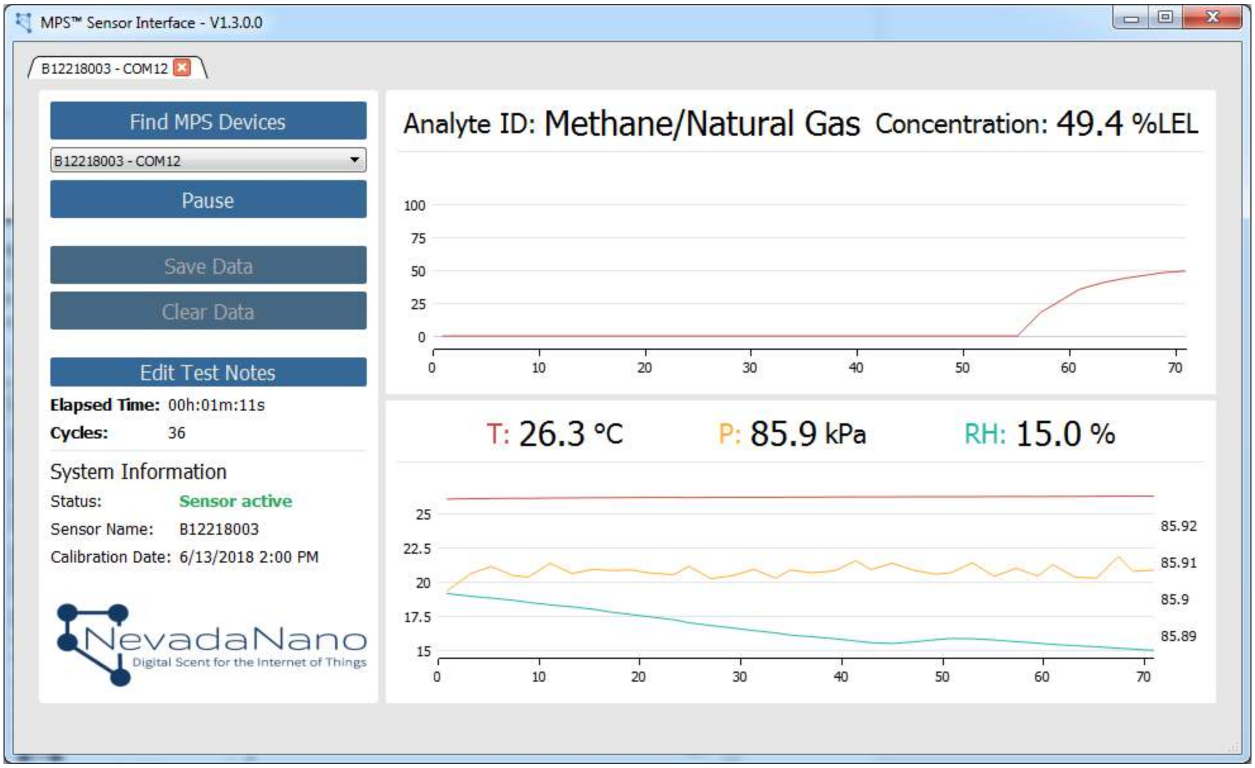

Figure 8 – MPS™ Flammables unit during testing.

1.5 Test Notes

The user must enter test notes by clicking the “Edit Test Notes” button any time prior to saving data. A set of example test notes is shown below.

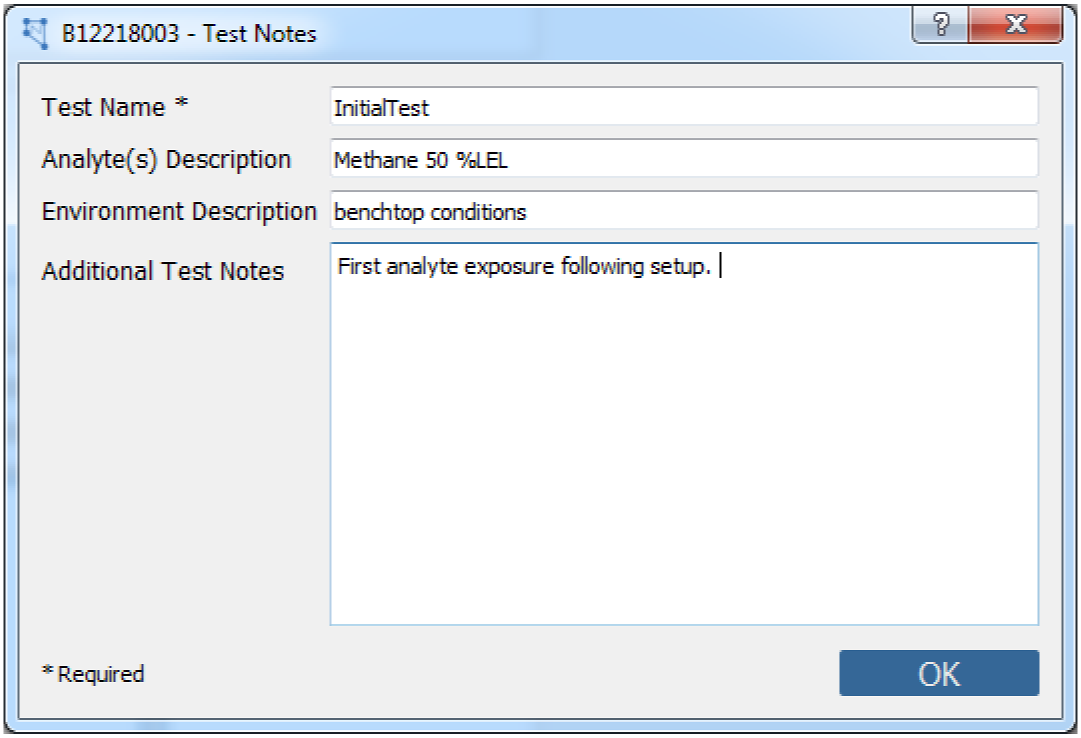

Figure 9 – Example test notes dialogue box.

After entering the experimental test notes, click “Save Data”. A dialogue box will appear to prompt the user to select a directory for saved test data. After saving, the user can now clear the data and begin another test.

1.6 Saving Data

Throughout a test, data are stored in a temporary directory. Once a test is complete, data can be saved to a drive location specified by the user. The folder created in this step is named using the following format.

Year_Month_Day-Time SensorName_testName

Here is an example:

2017_09_20-164411 B12218010_10_50_LEL MethaneTest

Avoid using hyphen and special characters (- , \ , /, %, &) when saving data:

The data folder will contain:

1. **timelog.txt** – This file provides the start, pause, re-start, and end times of a test. Here is an example:
   2017_09_20 - 13_03_00: Started
   2017_09_20 - 16_43_47: Paused
   2017_09_20 - 16_44_11: Data saved
2. **mpsData.csv –** This is a comma-separated-value formatted file that contains all the data from the test, organized in columns:

Time [s]	Cycle [#]	Temp., [C]	Press., [kPa]	Rel. Hum., [%]	FlamID	Concentration [%LEL]

3. **testNotes.txt –** This file provides a record of the test notes entered in the user dialogue box before saving.

General Guidelines

- Follow all applicable lab safety procedures.
- Using gas source concentrations below 100%LEL (50%LEL is common) will ensure that flammable conditions are not created in the test setup.
- Lecture bottles with gas concentrations near 50%LEL are commonly used for calibration of gas detection instruments in the field, and do not create unsafe (flammable) or unhealthy (toxic) gas conditions because the gases dilute quickly to safe concentrations when released into ambient air at 300 mL/min. Nonetheless, it's a good idea to ventilate the workspace, especially for prolonged tests. Implement a dilution/evacuation system to avoid exceeding the PEL.
- Operate the unit within the specifications (temperature, pressure, concentration range, etc.).
- Rapid changes in environmental conditions (i.e.: >10% RH or >10°C) over the course of a short time period (< 1 min) may cause the sensor to falsely identify the environmental change as a flammable gas. These conditions are not considered as normal use-case scenarios (i.e., they only occur in "artificial" laboratory testing protocols) and should be avoided. Should the unit be subjected to one of these conditions, the unit should be paused, data saved (if desired) and cleared. Then, the system should be restarted once the environment has equilibrated.
- The Nafion tubing is fragile. Avoid kinking or stressing the tubing to maintain adequate flow to the sensor.

Definitions

- *LEL (Lower Explosive Limit)* -- Lowest concentration (percentage) of a gas or vapor in air capable of producing a flash of fire in the presence of an ignition source (arc, flame, heat). Concentrations lower than the LEL are 'too lean' to burn.
- *PEL (Permissible Exposure Limit)* – a legal limit on the amount or concentration of a substance in the air to which a person can be exposed.

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